Aerospace Display Requirements: Aftermarket and New Vehicles *

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ABSTRACT

Vehicle displays share common requirements across broad spectra of land, air, sea, and space applications. Opportunities exist for technology co-investment in both revolutionary new display concepts and the affordable maintenance of currently fielded capabilities.

INTRODUCTION

Similar performance requirements exist for avionics and vetronics. Terminology and concepts that enable aerospace and automotive applications to be related to one another by performance specifications have been introduced by Hopper. [1] The principal of the performance specification is central to the new business paradigm in DoD, where the policy since 1993 has been to leverage the commercial market to the maximal extent possible. A summary of these principals is provided in Hopper. [2]

The market for both aerospace and automotive comprises two distinct portions: (1) original production by airplane and automobile manufacturers and (2) retrofit into an aftermarket comprising existing air and land vehicles. Indeed, initial insertion of a new display technology will proceed via the aftermarket before various factors, such as legal liability, permit its inclusion in new production vehicles. Currently the aftermarket is bigger than the OEM market for flat panel displays in both air and land vehicles. This paper presents a summary of the military display market as its exists in August 1999. The detailed report is available elsewhere. [3,4] This data will enable the initiation of a dialogue between the automotive and aerospace domains to ensure that maximal commonality can be sought to lower the costs in both application domains.

OVERVIEW OF MILITARY MARKET

We have been inventorying the number, function and size of military displays to establish a basis for the determination of opportunities for technology insertion. A total of 350 combat platforms and other defense systems throughout DoD have been explicitly documented, comprising an aggregate DoD installed base of over 322,000 displays. The 1997 interim report covered just 132 platforms and identified some 157,000 displays installed in defense systems, while the 1998 first comprehensive edition covered 263 platforms/systems and identified some 242,000 displays. A number of platforms and stand-alone systems remain to be incorporated in future reports. The growth in coverage is illustrated in Figure 1.

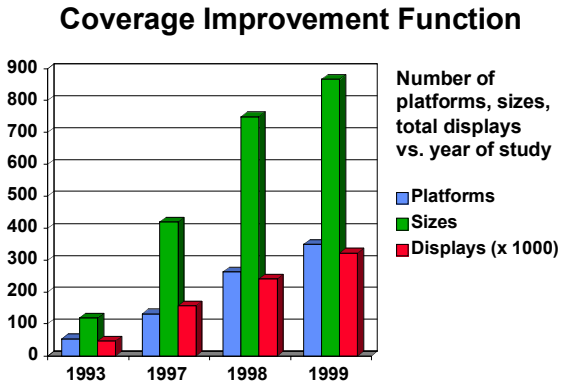

Figure 1. Growth in coverage of DoD displays.

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New growth in applications will add to these totals. For example, miniature displays in head-mounted systems are projected to add 114,000 new miniature displays (12-18 mm diagonal) in head-mounted applications in all four services.

The military displays market is specified by such parameters as active area and footprint size, and other characteristics such as luminance, gray scale, resolution, color capability and Night Vision Imaging System (NVIS) capability. A select grouping of funded, future acquisitions, planned and predicted pre-planned product improvements (e.g. cockpit kits), form-fit-function upgrades (e.g. preferred spares) are taken into account.

It is the intent of this paper to provide an overview of the DoD niche market, allowing both government and industry a timely reference to insure meeting DoD requirements for flat panel displays on schedule and in a cost-effective manner. The latter requires military integrators to leverage similar commercial markets such as automotive.

Similarly, the vanishing vendor syndrome (VVS) for older display technologies is becoming a growing, pervasive problem throughout DoD, which consequently must leverage the more modern display technologies being developed for civil-commercial markets. Automotive applications may have similar concerns regarding the viability of older display technologies in future vehicle products.

CURRENT DEFENSE MARKET

Method. The method for gathering information to this report was both "broad-spectrum" and "narrow-band." The "broad-spectrum" approach consisted in surveying reputable periodicals over the course of January 1995 through August 1999 (as follow-up to a similar approach used in 1991). These are primarily private publications whose professional bread and butter involved is getting at inside sources for accurate and up-to-date information on Army, Navy, and Air Force programs. These periodicals include *Defense News*, *Aviation Week and Space Technology*, *Aviation Magazine*, *Defense Week*, *International Defense Review*, *Naval Institute Proceedings* and *Air Force Magazine*.

The "narrow-band" approach on the other hand, entailed either fax, e-mail, telephonic or face-to-face inquiries of U.S. Army, Navy, Marines, Air Force and contractor program representatives regarding individual platforms. In regard to all these sources, one will find a thorough reference including dates, names, duty titles, office symbols, and telephone, fax, and/or e-mail numbers in Desjardins and Hopper. [4]

Assumptions. It is expected that every DoD military platform planned for retention beyond the year 2009 will experience at least one form-fit-function or other display upgrade during its remaining life-cycle. Indeed, such an upgrade can be anticipated for every 10 years of continuing life-cycle. Complete cockpit kit upgrades can be anticipated for every 20 years of lifecycle. Most DoD inventory systems are now at or past these 10-20 year milestones and are in need of upgrade or replacement based on technology of the next 20-40 years (FPD) rather than past, 60 year old, vanishing vendor technologies (CRT, electromechanical).

The likelihood that any given combat platform display upgrade program will make the decision to transfer from existing CRT and electromechanical (EM) display interfaces to those incorporating flat panel technologies becomes ever more certain as time and experience proves this latter approach superior in terms of performance, reliability and lifecycle maintenance cost. As this is report being written, there is already an epochal shift toward such technology insertion, with over 51% of the 322,000 DoD weapon system displays so far analyzed, having elected to convert to flat panel displays (FPD). The Quadrennial Defense Review (QDR) will determine which platforms, to what level and over what time frames, future technology insertions can be expected.

Anticipation of the display size for any new acquisition depends on a program knowledge of what is (a) in the Request For Proposal, or (b) on contract and briefed at the Critical Design Review. However, for existing systems, it is to be expected that any upgrade will likely--as a matter of simple economics--go the route of technology upgrade to FPDs. The replacement programs variously will be form-fit-function (F^3), form-fit-drop-in (F^2D) or instrument panel re-design (partial or full) to consolidate the functionality of several instruments into one integrated multifunction display (MFD). Hence, through accurate knowledge of existing CRT and EM display sizes, both in active area and instrument panel footprint, it is possible to reasonably anticipate the upper limit on size of the display for any upgrade involving flat panels. Furthermore, any existing display characteristic such as resolution, luminosity, chromaticity, gray scale, et cetera, serves as the minimum capability for the superceding technology (i.e., if there was a previous requirement for dimability, color, or NVIS, then it can be assumed there is at least that same minimum level of requirement in future applications). This is especially true wherever the combat system future role and mission remain constant. Lastly, in looking at foreign military sales (FMS), the assumption is

made here that any U.S.-built system is nearly equal in its market potential for U.S. military display vendors and integrators as far as future competed cockpit upgrades. Hence, assessments of potential demand for flat panel cockpit insertion should be based just as much on U.S.-built or licensed platforms owned by foreign militaries as those in U.S. inventories. The numbers in this report pertain to U.S. DoD military demand only and should be multiplied by a factor of about two (2) to determine the full market available to DoD contractors. Offset agreements come to play in FMS programs, of course, and some display component vendor selection might be affected.

Procedure. The procedure for this report was to review, edit and record reliable pieces of information on each and every DoD cockpit, crew-station, command or control center, training system and portable device covered by major publication sources. Information sought pertained to number and kind of display hardware per application (i.e., platform), schedules of development and delivery, display module footprint and active-area size, congressional or programmatic decisions, and, where possible, ancillary characteristics of existing or upgrade displays such as technology base, resolution, color, gray scale, NVIS compatibility, etc. Where necessary, system details were obtained through direct contact with acquisition and logistic program offices, or even the private industry contractor.

Edited textual information from all sources became the basis for the Appendix. Then each platform fleet was analyzed for total number of displays by size, and the results were tabulated across all DoD systems. The resultant numbers by display image size and technology are presented in Figures 2 and 3.

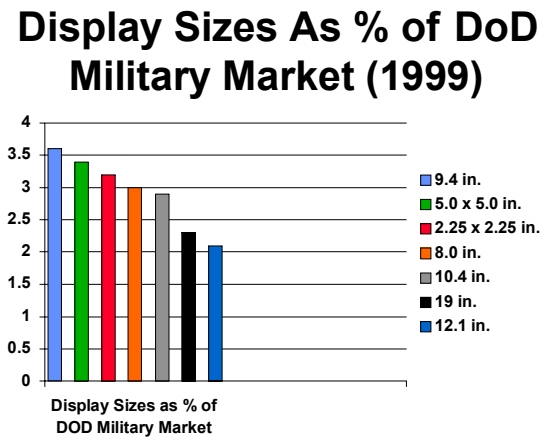

Figure 2. Defense displays by size (top seven).

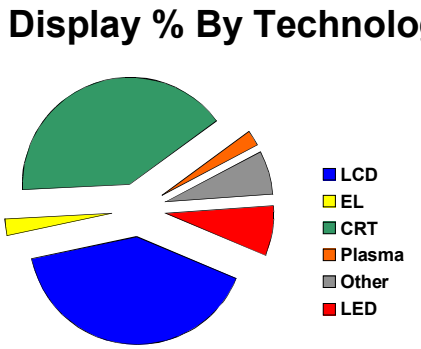

Figure 3. Defense displays by technology.

FUTURE AEROSPACE DEFENSE MARKET

Surfing. The aerospace/defense display challenge is to leverage the commercial market to the maximum extent possible. Surfing is an apt analogy, with the commercial market represented by waves of technologies and products (high energy & funding levels) and aerospace/defense as the surfer applying relative small amounts of energy (funding) to ride to shore (achieve a low volume albeit tough performance parameter application). An overall goal is to rely on commercial display technologies of the future rather than the past to significantly reduce life cycle costs.

Grand challenge. The grand challenge for display technology is to move towards the limits of the human visual system: 1 billion pixels in true 3D at full motion video (60 Hz up) and greyscale (8 bits per primary). Goals for the next 20 years include the capability to put pixels on the head, vehicle/console, or wall according to the following timeframe (full color & video in all cases): 4-6M, 10M, and 35-210M by 2000, 2005, and 2010, respectively. This defense display technology vision is illustrated in Figure 4.

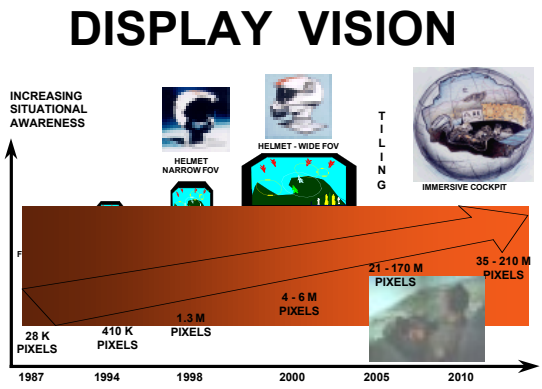

Figure 4. Aerospace defense display vision.

SUMMARY

Across DoD systems approximately 51% of the total displays are implemented with, or are planning to be implemented with, a form of flat panel. Within the flat panels, 79% are LCD or AMLCD. Among total DoD displays, 40% use, or plan to use, LCD flat panel technologies. Some 10% of total DoD displays use non-LCD flat panel technology, such as electroluminescent or plasma. Approximately 41% of DoD displays currently use a CRT. The remaining 7% of total DoD displays are incandescent or electromechanical. Given the dramatically smaller mean time between failure rate of installed older technologies (CRT and EM, in particular), relative to flat panel technologies, coupled with a dwindling industrial base and consequently increasing per unit purchase price for the old technologies, it can be anticipated that the part of the current DoD inventory using older technologies will, at some point, require technology upgrade via form-fit-function, form-fit-drop-in or instrument panel re-design

Some 503 out of 866 display sizes are unique to only one DoD program. Also, 36 of these 503 sizes are "singularities" (i.e. numerically unique). We recognize that, short of an instrument panel re-design (partial or full), existing crewstation configuration imposes a limitation to the latitude any one program faces in terms of display size conversion.

The approximately 866 display sizes currently in use can be grouped into size categories. The 9.4 in. diagonal active area display, for instance, represents 3.6% of total DoD displays (half of these are AMLCD). The 5.0 x 5.0 in. size represents 3.4% (92% of these are CRT). The 2.25 x 2.25 in. size accounts for 3.2% (99.5% of these are AMLCD). The 8.0 in. diagonal size represents 3.0% (100% of which are AMLCD), while the 10.4 in. diagonal size represents 2.9% (of which 96.3% are AMLCD). The 19.0 in. diagonal size represents 2.3% (100% of which are CRT). This data, correlating sizes to technologies, should be used as baseline information ("what is") in any acquisition program involving displays (to decide "what will be").

CONCLUSIONS

The present results for display sizes signal the rallying point about which the process of achieving greater commonality can evolve. It is the recommendation of this report, both to DoD and to industry, that they take advantage of this information to reduce, over time, the number of unique sizes. The number of displays will grow beyond those currently in inventory as new crewstation concepts increase resolution beyond the 1 million pixels in currently fielded systems to tens and hundreds of millions of pixels and add some measure of true 3-D.

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